339

METEOROLOGICAL OFFICE
14 AUG 1970
LIBRARY

Restricted Circulation

This paper is not an official document; it is for information only and reference cannot be made to it in any printed publication without the permission of the author.

Agricultural Memorandum No.339

0105975

Diseases and Pests in a Drought

By G. W. Hurst
Meteorological Office, Bracknell

General

This account is written mainly from the viewpoint of drought associated with irregular distribution of rainfall in many parts of the world, and not from that of consideration of desert areas subject to lengthy rainless periods. Territories concerned therefore mostly lie in the temperate zones, as the equatorial belt is almost drought free, and regimes between the equatorial and temperate zones have longer or shorter regular almost continuously dry seasons.

The effects of drought, especially if prolonged, are popularly considered adverse to agriculture, and more so in summer than in winter. This is of course in general true, but drought has a measure of compensation in almost eliminating economic losses from some diseases and pests. Summer drought in most parts of the world is associated with warm, sunny weather; winter drought is often cold, and may be dull or clear.

Most attention will be focussed on diseases and pests as they affect vegetative growth, but a few animal diseases exist, the incidence of which is affected by drought, and these are briefly considered.

It must be stressed that this is essentially a brief survey of a very wide subject, and a few references are given which hint at the relevant literature. Like many other biological/meteorological problems, considerable work has been done on the physiological side, but the amount of reliable field work is very limited.

Pests

Dry weather has more effect on population changes and survival of some pests than others, and probably most affected are the leaf feeding insects and those part of whose life cycle is spent just below the soil surface.

Aphids are certainly affected by drought, but effects are complex, and different species do not react in precisely the same way. Many aphids have alternate hosts, and the Apple-grass aphid, for example, goes from grass to orchards in late summer. Drought at some time a few weeks before this movement will dry the grass, and reduce populations going to the orchards. The Damson-hop aphid by contrast migrates in early summer from trees to hop plants. On the spring host, colonies tend to concentrate at the tips of actively growing shoots. Drought during late spring may reduce or stop shoot growth, with the result that the food supply is exploited more rapidly, the migration period is shortened, and control of infestations on hop is simplified. However the relationship between populations and host

FGS Stock 34

G14125/GEZ/8/70/100

plants in drought is complex. One effect is that less woody growth, more crowding and the high temperatures usually associated with dry weather (and therefore more rapid biological processes) might lead to a population explosion. A side effect of drought is to increase amino-acid content of leaves and improve nutrient and attractiveness of plants; this factor of improved nutrient may well be more important to population increases than the hot weather which usually goes with drought. The result therefore can be again to increase populations; the drought level is assumed not to be so intense as to constitute a direct threat of population survival. A further benefit to aphids of dry weather is that certain diseases such as Entonophera are inhibited because moisture is required for successful germination.

In general therefore plants stand to suffer more from aphid activity in drought than in wet weather; this tendency may be heightened by the water-stress weakened plants possessing less ability to withstand attack. A slow-moving crop may be held back at the susceptible young growth stage for a longer period, and late insect immigrants may still find the plant attractive in nutriment; the period of risk for the plant will therefore be longer. A final consideration is that aphids may sometimes be washed or splashed off plants in heavy rain; this obviously cannot happen in drought - but the risk may still exist during this period from irrigation spraying.

Rather similar in showing protraction of period on the plant, larvae of gall midges of cereals for example do not leave the cereal ear unless it is moist, so in drought conditions, fully fed larvae accumulate, and drop to earth in very large numbers after rain; whether this movement is gradual or sudden, early or late, may therefore depend on drought conditions. The larvae have all burrowed to 2 cm or more depth within a couple of hours, but if drought returns, desiccation of pupae will follow (especially if hot) and high mortality will occur.

Eelworms are strongly affected by drought, in that free movement is not possible without water. In dry soil therefore they can become almost completely desiccated, but recover from this state of suspended activity when drought ends; eggs rely upon moisture for hatching, but they too can remain undamaged for considerable periods of drought.

Many species of beetle and fly spend part of their life cycle as eggs or larvae below ground, and drought at this time causes high mortality in many cases. Examples include the leatherjacket (crane fly) which suffers severe egg mortality with late summer drought, or larval mortality after hatch in early autumn drought, though the spread of oviposition and hatching blurs distinction between the two periods. The Colorado potato beetle can suffer because of spring or early summer drought and mortality in hibernation, and later at the egg/larval stage in summer; the insect may also suffer in larval and adult form on plants because of shortage of food in severe drought. The question of depth of hibernation arises with the Colorado beetle, and in dry soil the insect digs more deeply. Other pests such as wireworms and slugs also dig more deeply in dry weather to reach a moist layer. Similarly, grasshopper numbers occasionally reach big proportions in territories such as South Australia after a season or two of favourable weather, but prolonged drought in summer causes high

mortality to eggs in the soil (where they remain from late spring to early spring the following year).

The object of this note is not to discuss desert conditions, but it is interesting that although eggs of the desert locust are drought hardy, because of the relative impermeability of the cuticle covering the shell, a measure of moisture in the breeding grounds is needed after hatching to make good moisture deficiencies. Many animals are indeed drought hardy for life (such as lizards and ticks) and others only seasonally; thus the lucerne flea requires very moist conditions for most of its life, but its eggs are drought hardy.

Many insects such as moths do not react in very obvious manner to drought as such, though there is biological response to the associated warm sunny weather, and population increases occur; provided suitable food is present, they flourish. Caterpillars and leaf eaters generally show no very strong reaction to drought (not being affected by the quality of nutrient) but wilted plants may be left in mass migration. Some insects are equipped to withstand extraordinarily dry conditions; larvae of the moth Ephestia for example can survive in flour oven-heated at 105°C and stored in a desiccator over strong sulphuric acid.

It will be realised from the above discussion that the timing of the period of drought can be very significant. Early summer drought may reduce seriously populations of particular insects through food shortage, but numbers can quickly be made up later. Late drought and big population reductions however would preclude recovery of the insect populations in that year. Most of this discussion on drought assumes that the summer half of the year is under consideration - in winter, drought is seldom of great importance because most of the insects are quiescent. However, the question of survival in shallow soil may arise, with snow cover keeping temperatures below 0°C, and the lack of snow in a dry winter causing high pest mortality because of very low soil temperatures.

An interesting effect of drought is to increase the amount of abrasive dust blown about in the air in many areas. This can cause damage to plants, and whereas some pests such as scale insects are more or less plugged into the plant and are unaffected, many of their predators or parasites may be injured or killed, or suffer from reduced food supply.

Drought may have important application on control measures to be taken against pests. Chemical insecticides may have to be applied more often to a plant to control pests which remain longer than usual, and possible side-effects by the chemical on the plant may be greatly aggravated by water stress. The use of pathogen sprays may also be drought affected, because many of the bacteria being sprayed to cause insect diseases need moisture for sporulation. The efficiency of systematic insecticide applied to the soil tends to decrease in drought conditions even though much of the insecticide may be present in the soil; as soon as it rains, the insecticide is again taken up by the plant, and insects that have established themselves in the meantime may then be killed.

Animal Diseases

Apart from considerations of whether animals can get adequate food for their development, several diseases have some relationship to rainfall amount, often in its effect on soil moisture. With dry soils there is usually much less opportunity for development of diseases or pests inimical to domestic animals. Drought may potentially therefore play a part in reducing the incidence of some diseases.

The severity of outbreaks of the parasitic disease liver fluke in sheep were found many years ago to depend mainly on wetness of (late) summer. This is because the flukes spend part of their life cycle in snails, which are much less numerous if the ground is dry, and because of the greater mortality of fluke eggs in dry weather. Drought in late summer strongly decreases subsequent incidence of disease.

Gastro-enteritis in cattle, associated with larvae of worms among grass, has main periods of incidence in early and in late summer; in early summer, outbreaks are more widespread following dry conditions in the previous late summer and early autumn, whilst in late summer, dry weather in July and August lead to further outbreaks. Strictly, the moisture of the soil is the main factor in this context, but drought conditions in any summer month usually leads rapidly to suitable soil moisture deficits.

The spread of foot-and-mouth disease has also been related both to wind and rain, and for widespread dissemination of the disease, washout of the virus (however carried) by rain seems essential.

Plant Diseases

Of the different types of pathogen carrying plant diseases, the fungi are the most affected by drought conditions. Most fungal pathogens require moisture for infection and are therefore more serious in wet weather, but there are important exceptions. Thus powdery mildews often flourish in dry weather, though sporulation may be reduced in the absence of moisture, so prolonged drought can therefore prevent massive build-up, but semi-dry weather can lead to widespread severe attacks. The downy mildews on the other hand are virtually eliminated by drought. An interesting example of the effect of dry and wet conditions on these two types of mildews has been reported from the Salinas valley in California, United States, where lettuces are affected both by a powdery and a downy mildew; the downy mildew is present in cool wet areas and the powdery mildew in hot dry areas, but in part of the valley conditions are moderately favourable for both diseases, which can in fact occur together.

Considering drought effects on particular crops, the potato is of special interest because it is widely cultivated, and is subject to many diseases. The best known, blight, which is a downy mildew, is virtually precluded under drought conditions. Common scab, however, can be severe on the tubers after dry weather in early summer, but irrigation particularly in the four weeks following the start of tuber formation will prevent infection. Potato wart disease (subject to quarantine regulations in

some countries) is absent in drought - and indeed based on summer rainfall, maps can be drawn of areas free from, and prone to, the disease. In contrast, plants may be more vulnerable to wilt diseases in drought, though the effects of infection may apparently be merely drought symptoms. The importance of the timing of drought is particularly well brought out by these examples - early drought may lead to severe scab, and late drought to wilt.

On cereals the distribution and incidence of three rusts in relation to drought is interesting. Brown and black rusts when they occur in temperate countries have often originated in the semi-tropics (e.g. Mediterranean areas of Europe, where they thrive) and if the uredospores are carried by winds to areas subject to relatively dry weather, the rusts will become established there. Yellow rust, however, which is indigenous in temperate areas is adversely affected by summer drought though the curtailment of its spread may be primarily due to ultra-violet effect of sunlight rather than the dryness.

Scorch is another drought-associated cereal disease; affected plants show drought symptoms, but are often also infected by fusarium foot-rot. With wilt diseases, the effect of drought in reducing root growth usually does not encourage the fungi to develop more on the smaller root systems. A side-effect with take-all fungus is that autumn and winter drought inhibits rotting of infected stubble, and allows it to survive longer as a potential source of infection for subsequent cereal crops.

Apple scab infection occurs only after comparatively prolonged leaf wetness, and drought conditions in early spring will normally preclude outbreaks of the disease, though exceptionally, leaf wetness may be maintained in a cloudy moist regime without the occurrence of measurable precipitation.

These examples show that drought, especially in association with hot and dry weather, can affect not only the incidence of various diseases but can very markedly affect the ability of the fungi to infect and spread and so to cause serious losses.

Acknowledgements

Much helpful information and advice has been received from several quarters to enable the author to write this note. In particular appreciation is expressed to:

G.H.L. Dicker,	East Malling Research Station, Maidstone.
K.S. George,	Plant Pathology Laboratory, Harpenden.
J.M. Hirst,	Rothamsted Experimental Station, Harpenden.
C.G. Johnson,	Rothamsted Experimental Station, Harpenden.
F. Joan Moore,	Plant Pathology Laboratory, Harpenden.
B.D. Moreton,	NAAS, South-east Region Sub-Centre, Wye.
H.F. van Emden,	University of Reading.
M.J. Way,	Imperial College of Science, Silwood Park.

References

No attempt has been made to collect a list of references covering the various aspects touched upon in the above account. A few are, however, quoted below, and these should constitute a satisfactory starting point for any particular line of interest.

ANDREWARTHA, H.G. (1961) Introduction to the study of animal populations. Methuen, London. pp. 1-281. English, 237 Ref.

ANDREWARTHA, H.G. and BIRCH, L.C. (1954) Distribution and abundance of animals. Univ. of Chicago Press. pp. 1-782. English, over 1000 Ref.

BARNES, H.F. (1956) Gall midges of economic importance. Vol. VII, cereal crops. Crosby Lockwood, London. pp. 1-261. English, 526 Ref.

BOJMANSKY, V. (1960) Ecology and prognosis of potato wart disease. Synchytrium endobioticum (Schilb.) Perc. Slovan. Akad. Vied. Bratislava pp. 1-227. Czech (English, French and Russian chapter summaries), 160 Ref.

BOUGHLEY, A.S. (1949) Ecology of fungi which cause economic plant diseases. Trans. Brit. Myc. Soc., London. XXXII, II, pp. 179-189. English, 66 Ref.

BUXTON, P.A. (1955) Natural history of Tsetse flies, an account of the biology of the genus Glossina (Diptera). Mem. No. 10. London Sch. of Hyg. and Trop. Med. pp. 1-816. English, 400 Ref.

EDNEY, E.B. (1957) Water relations of terrestrial arthropods. Cambridge Monogr. in Exp. Biol. No. 5. pp. 1-115. English, 250 Ref.

JOHNSON, C.G. (1969) Migration and dispersal of insects by flight. Methuen, London. pp. 1-763. English, over 1500 Ref.

LAPWOOD, D.H. and HERING, P.F. (1968) Infection of potato tubers by common scab during brief periods when the soil is drying. Eur. potato. J. 11. pp. 177-187. English (French and German summaries), 15 Ref.

MILNE, A., LAUGHLIN, R. and COGGINS, R.E. (1965) 1955 and 1959 population crashes in the leatherjackets in Northumberland. J. Anim. Ecol., Oxford. 34. pp. 529-544. English, 7 Ref.

SCHNATHORST, W.C. (1962) Comparative ecology of downy and powdery mildews of lettuce. Phytopath. 52. pp. 41-46. English, 20 Ref.

European Plant Protection Organisation. Annual Reports approximately 1947 onwards (1966 most recent available) covering separately:

Colorado potato beetle
Potato root eelworm
Potato wart disease
E.P.P.O., Paris. English and French, Refs. as necessary.

World Meteorological Organisation. Many technical notes. For example:
No. 55. (1963) Influence of weather conditions on occurrence of apple scab. pp. 1-41. English (French, German and Russian summaries), 34 Ref.

No. 69. (1965) Meteorology and the desert locust. pp. 1-310. English (French, German and Russian summaries), many Ref.

No. 99. (1969) Meteorological factors affecting the epidemiology of wheat rusts. pp. 1-143. English (French, German and Russian summaries), over 350 Ref.

Any comments or suggestions on this paper should be sent to the author.

Meteorological Office
Bracknell
Berkshire

August 1970

G14126/GEZ/8/70/100